adverse cardiac events in high-risk patients undergoing noncardiac operations. In fact, postoperative myocardial ischemia as detected by Holter electrocardiographic monitoring confers a 9.2-fold increase in the odds of a cardiac event. No other clinical, historical, or perioperative variable was associated independently with adverse cardiac results, including the cardiac risk index, a history of previous myocardial infarction or congestive heart failure, or the occurrence of ischemia before or during an operation. Accordingly, increased attention and resources should be focused on the postoperative period. Clinical trials of perioperative antiischemic therapies are currently under way. The results from these trials will determine whether the incidence of perioperative cardiac morbidity can be reduced by the prevention of postoperative ischemia.

JACQUELINE M. LEUNG, MD
San Francisco, California

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Sedating Patients in Intensive Care Units

ANXIETY, SLEEP DEPRIVATION, and pain are extremely common problems in patients in intensive care units and can lead to delusions, delirium, or psychosis. The neuroendocrine stress responses often associated with noxious conditions can produce deleterious hemodynamic, metabolic, nutritional, and immunologic changes. Inadequate control of any of these problems frequently results in unnecessarily large doses of sedatives. Coughing with an endotracheal tube and fighting the ventilator complicate the management of patients on ventilatory support. Asynchrony between spontaneous ventilatory efforts and mechanical breaths predisposes patients to pulmonary barotrauma, interferes with alveolar gas exchange, and increases the work of breathing. Neuromuscular paralysis for the control of inappropriate (central) hyperventilation mandates that sedation also provide amnesia.

Older sedation practices relied primarily on intermittent intravenous doses of morphine sulfate or meperidine hydrochloride. Diazepam or pentobarbital was given when amnesia or hypnosis was required. Unfortunately, boluses of these long-acting agents often caused serious circulatory and respiratory depression, and the high doses of opiates decreased gastrointestinal motility and prolonged ileus.

Midazolam hydrochloride, a short-acting benzodiazepine, has a pharmacokinetic profile that readily allows titration to effect when given by continuous intravenous infusion. Loading is best achieved by 0.5-mg increments followed by an infusion of 0.015 to 0.2 mg per kg per hour. Respiratory or circulatory depression is generally minimal, and even after prolonged infusions its effects usually dissipate within two hours after the infusion is stopped. The latter facilitates a rapid weaning from mechanical ventilation and neurologic evaluation. Withdrawal symptoms are uncommon, but tolerance may develop in some patients.

Supplementing midazolam is important whenever a patient has substantial pain, is on a ventilator, or tolerance develops. A concomitant infusion of an opioid or ketamine hydrochloride augments the sedation, provides analgesia, and reduces drug requirements. Adding fentanyl citrate, 0.5 to 2 μg per kg per hour, sufentanil citrate, 0.05 to 0.2 μg per kg per hour, or alfentanil hydrochloride, 5 to 20 μg per kg per hour, can produce excellent analgesia and reduces midazolam requirements. Alternatively, ketamine, 0.15 to 0.5 mg per kg per hour, can also provide powerful analgesia. Unlike opioids, ketamine is a bronchodilator and mild respiratory stimulant. Psychotomimetic reactions, such as hallucination and nightmares, are uncommon when ketamine is combined with a benzodiazepine.

Propofol, a short-acting intravenous anesthetic with a rapid onset and termination, is an excellent sedative at low doses—1 to 6 mg per kg per hour. Dose-dependent respiratory depression and hypotension can be observed after administering a bolus but are generally minimal when propofol is given by infusion at this dose range. Propofol's principal advantage is that its effects usually dissipate within 15 to 20 minutes after the infusion is stopped. Withdrawal symptoms have been reported following prolonged propofol infusion.

MAGED S. MIKHAIL, MD
DURAIYAH THANGATHURAI, MD
Los Angeles, California

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Perioperative Temperature Control

HUMANS NORMALLY MAINTAIN a core body temperature near 37°C. This temperature is maintained because deviations of only a few tenths of a degree trigger thermoregulatory responses, including vasoconstriction, shivering, active vasodilation, and sweating. General anesthetics profoundly impair normal thermoregulatory processing. For example, the core temperature triggering vasoconstriction is decreased from about 37°C to about 34°C by halothane, nitrous oxide and fentanyl citrate, nitrous oxide and propofol, and isoflurane. The exact triggering threshold depends on the anesthetic type and dose, but is similar in infants, children, and adults. In contrast, the core temperature triggering sweating and active vasodilation is increased about a degree by surgical concentrations of isoflurane and enflurane. The interthreshold range (core temperature not triggering thermoregulatory responses) thus is increased by general anesthesia from about 0.6°C to about 4°C.

Most patients become hypothermic during surgical procedures, and hypothermia usually develops in three distinct phases. During the first hour, the core temperature decreases about 1°C. Surprisingly, undressing patients in a cold room and washing their skin with fluid that is subsequently allowed to evaporate contributes little to the hypothermia. Anesthetic-induced vasodilation only minimally increases heat loss from the skin surface. Similarly, inducing anesthesia only minimally reduces metabolic heat production. Core hypothermia actually results because vasodilation allows heat in warm core tissues to escape into the cooler peripheral thermal compartment. This reduces the core temperature, increases the peripheral temperature, and leaves the body heat content unchanged.

Redistribution hypothermia is followed by a slow linear decrease in the core temperature, lasting two to three hours. This linear decrease apparently results simply from heat loss exceeding metabolic heat production. Finally, after three to four hours of anesthesia, the core temperature becomes constant and does not decrease further even during prolonged surgery.

Intraoperative hypothermia is most common in infants and children because of a high surface area-to-mass ratio and in elderly patients because thermoregulatory responses are impaired. Mild hypothermia—2°C to 3°C below normal—protects against hypoxia, ischemia, and malignant hyperthermia. Consequently, hypothermia is appropriate in patients in whom ischemia can be expected, such as during carotid and neurosurgical procedures. Conversely, hypothermia decreases drug metabolism, impairs coagulation, decreases resistance to wound infections, and provokes postanesthetic shivering. Most patients should therefore be maintained at normal temperature. Hypothermia is best treated using a high ambient temperature or forced-air warming. Circulating-water warmers placed over patients substantially decrease heat loss but are relatively ineffective when positioned under patients. Warming intravenous fluids is critical when large volumes are administered. Airway heating and humidification transfer little heat and are not worth the expense in adult patients.

DANIEL I. SESSLER, MD
San Francisco, California

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Postoperative Apnea Syndrome in Premature Infants

THE PREDISPOSITION OF preterm infants to episodes of apnea in the postoperative period has been recognized for a decade. What progress has been achieved during this time in our understanding of the etiology of this problem, and how should these patients be managed?

Infants younger than 45 weeks of conceptual age (conceptual age is the sum of gestational age and postnatal age) are more likely to be affected. Although conceptual age is a significant predictor of problems, there is also a suggestion that infants who were born at an early gestational age are at a further increased risk. In addition, a number of other predisposing factors have become recognized. These include anemia, a history of the respiratory distress syndrome, persistent chronic respiratory disease, and previous apneic episodes. Although a history of apnea is clearly important, infants with no previous episodes of apnea may also be at risk to suffer an apneic episode in the postoperative period. Apnea usually occurs within the first few hours after the operation, but in smaller infants may occur much later. The apnea is central in origin in most instances, but obstructive apnea may also occur. Apnea is more likely to occur after general anesthesia, but life-threatening apnea may rarely occur even if only regional analgesia has been used.

Current recommendations are that the management of preterm infants generally should include hospital admission and careful postoperative monitoring of all surgical patients who are younger than 50 weeks of postconceptual age. Such infants should be treated in hospitals that have a neonatal service and a neonatal intensive care unit. After the operation they should be monitored with an apnea alarm in an area under close nursing supervision for 12 to 24 hours or more, depending on their history. The presence of anemia, chronic respiratory disease, or persistent episodes of apnea are indications to admit older infants. The use of spinal or caudal anesthesia may be advantageous, especially in those infants with a previous history of prolonged ventilatory support.

Intravenous caffeine therapy, 10 mg per kg, given at the induction of anesthesia has been suggested to reduce the danger of postoperative apnea, but close postoperative observation is still recommended. At present, the use of caffeine therapy is not common. The influence of theophylline therapy on the danger of postoperative apnea has not been fully studied.

DAVID J. STEWARD, MB
Los Angeles, California

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Autologous Blood Transfusion Therapy

THE PROBABILITY THAT homologous blood transfusions will transmit infectious diseases has decreased with thorough blood donor screening and sophisticated laboratory testing. The risk of contracting a potentially lethal infection nonetheless remains finite (1 in about 40,000 units for the human immunodeficiency virus [HIV]). Autologous blood transfusion is the safest alternative for some patients having surgical procedures. In California, whenever there is a reasonable possibility that a patient having a procedure will require a blood transfusion, the patient must be informed of the risks and benefits of the various options for managing transfusion therapy.

Few surgical procedures are commonly associated with a critical volume of blood loss that warrants transfusion therapy. Patient-specific factors such as size, cardiovascular status, pulmonary function, and hematologic profile are important in decisions relating to transfusion. Autologous blood for transfusion in the perioperative period may be obtained by preoperative autologous donation, normovolemic hemodilution, intraoperative blood salvage, or postoperative blood salvage. Alone or in combination, these can decrease or eliminate the need for homologous blood transfusion.

As many as four to five autologous units can be safely donated preoperatively during the six-week shelf life of erythrocytes collected in adenine-supplemented preservatives. The plasma can be freshly frozen. The hematocrits of autologous donors are monitored, and treatment with oral iron is routine. The value and role of recombinant human erythropoietin remain under investigation. Because the morbidity of donation is predominantly related to vasovagal reactions, clinically adverse hemodynamic sequelae are more likely in patients with cardiac or cerebrovascular disease. Older children and elderly patients can qualify, but Jehovah's Witnesses will not accept this procedure. Autologous units are tested for HIV, hepatitis B and C, syphilis, and the human